Study: Power Grids 2030+

Management Summary

Climate change is one of the greatest social challenges of the 21st century. Stopping it, and reducing the effects and damage already done, will be the central task of current and future generations. The German government has acknowledged its responsibility and has set extensive climate policy goals. These include making Germany climate-neutral by 2045. In order to reach this goal, everyone must contribute to this. In addition to increasing energy efficiency, it is particularly necessary to decarbonise the electricity sector by significantly increasing the share of renewable energies. To this end, accelerated expansion of electricity generation from renewable energies must be consistently pursued, and electrification accelerated. Climate-neutral, flexibly available power plants should support the electricity market as a backup when load peaks are not covered by fluctuating renewable energies. In the future, sectors such as buildings and transportation are to meet their needs with green electricity instead of conventional energy sources. According to the coalition agreement, the share of renewables is to rise to 80 percent by 2030. Electrification will also significantly increase the gross electricity demand. These goals can only be achieved with a sufficient power grid being expanded in time to support a climate-neutral energy system.
So far, the technical design of a "climate neutral grid" has hardly been considered. This climate neutral grid is the power grid infrastructure for the period after 2030 that allows the transformation to an energy system based entirely on renewable energies – triggered by the climate targets – to be guaranteed while maintaining security of supply.

This study will now show

- which technical requirements a climate neutral grid will have to fulfil from 2030+,
- with which technical and operational requirements (functionalities) this can be achieved, and
- which legislative/regulatory adjustments as well as technological innovations will be required immediately to ensure that the climate neutral grid is available in time.

In a six-layer model – based on publicly available scenarios for the energy system 2030+ – the impact on power grids is determined, requirements are defined, functionalities for power grid operation are elaborated, and finally the necessity for action is described.
The requirements for power grids change mainly due to the replacement of large power plants by more numerous, but also much smaller wind and photovoltaic energy plants as well as the electrification of the heat and transport sectors.
In the next 15 to 20 years

- the installed capacity of wind turbines will increase by a factor of three to four up to between 180 and 220 GW,
- the installed capacity of photovoltaic systems will increase by a factor of almost six up to between 250 and 350 GW. This will then comprise approx. 12 - 15 million photovoltaic systems in Germany.

Apart from offshore wind turbines, most of these systems will be connected in a decentralised, small-scale manner, primarily at the distribution grid level. Their generation output is largely dependent on wind and solar.

- The number of charging stations for e-mobility will increase 30-fold to 15 to 20 million, and the number of heat pumps will increase 14-fold to 12 to 15 million. This will then mean installed capacities of around 700 to 900 GW for these two consumer groups alone (compared with around 45 GW today).

This will mean turning away from the centralised unidirectional energy supply, that still dominates today, to a decentralised bidirectional energy supply with a large number of power generation plants. At the same time, the new types of consumers will offer flexibilities that can be used to adjust the supply-dependent sources, where powerful communication and data processing will be required for their active control.

Nevertheless, in special extreme situations (such as high load, low feed-in or low load, high feed-in), large regional power imbalances can occur up to the high-voltage level. The tasks are therefore changing fundamentally, particularly at the high-voltage level. In the past, this level had a clear task, namely the regional distribution of feed-in from the extra-high voltage level. In the future, however, it will have to deal with situations that vary greatly in terms of time and space, ranging from the further existing distribution tasks to the extreme opposite, i.e., the collection of power from lower voltage levels.
In order to further guarantee a secure and reliable energy supply for Germany under these conditions, it is necessary to have complete knowledge of the network status down to the low-voltage level, and at all times. This is the only way to enable a highly automated operation, which is a prerequisite for responsive grid operation with regional load balancing and dynamically optimised grid utilisation.
This study identified a total of 39 functionalities as prerequisites for meeting these requirements. Such functionalities in the grid usually require the coordinated installation of technical components by several players. For example, a system operator will only gain transparency about the behaviour of distributed feeders if distribution grid operators install appropriate sensors, and a communication path is available. Therefore, the development of new functionalities in the grid often cannot be left to individual actors but must be approached in a coordinated and timely manner.
Of the 39 functionalities that will be required in the future, only two are currently in widespread use. For all others, adjustments to the regulatory framework and, in some cases, further technical developments and standardisation will be required. Especially for the essential functionalities, the necessary legal changes must be made in a timely manner.

Examples of essential functionalities are:
- continuous network status recording and forecasting at all network levels,
- dynamic balancing of feed-in and offtake with the available network capacity,
- predictive system management with sensible utilisation of the resource limits,
- provision of standardised, digital connectivity for players connected to the network as a basis for new services and business models.

The use of the functionalities identified requires an almost complete digitalisation of the grids. This includes:
- demand-driven data provision from/for all actors,
- complete data images of the grid in real time,
- interoperability of sensors and actuators,
- grid-state adaptive protection technology,
- cyber security.

In summary: In order to be able to control decentralisation, supply dependency and volatility of the future power system while ensuring security of supply and economic efficiency, the climate-neutral grid must include these new functionalities. It must therefore be technically enhanced compared to the existing grid. This further development must be coordinated and implemented with everyone – the network operators, the network users and the network service providers. Digitalisation will play a central role. The legal and regulatory framework must bring all players to seek out and plan new solutions in line with the energy transition, and in a timely manner. Only by doing so, their timely introduction can be set in motion so that the necessary functionalities are available in the grids after 2030.

The prerequisites for this must be created now. In detail, this means:
1. The climate protection targets can only be implemented if the functionalities required in the future for the infrastructure – the climate neutral network – are defined now and implemented swiftly in the coming years.
2. It is a holistic transformation – simultaneously at all network levels and during grid operations while maintaining security of supply.
3. Where necessary, the capacity and structure of the grids must be adapted to the new requirements.
4. The climate neutral grid is therefore a grid, which has been further developed not only structurally but also technically, compared to the past.
5. Digitalisation is the key to intelligent and transparent grid operations.
6. Insofar as new solutions are available to realise necessary system-wide functionalities – which are required for the cooperation of several players – their use cannot be left solely to the business decisions of individual market players. Instead, the implementation must be ensured and coordinated from an economic point of view by means of a binding legislative and regulatory framework.

Contact
Anke Hüneburg • Geschäftsführerin • Fachverband Energietechnik •
Tel.: +493030696013 • Mobil: +49 162 2662 360 • E-Mail: Anke.Hueneburg@zvei.org

ZVEI e. V. • Electro and Digital Industry Association • Charlottenstraße 35/36 • 10117 Berlin • Germany
Lobbying Register ID.: R002101 • EU Transparency Register ID: 94770746469-09 • www.zvei.org

14 July, 2023